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Anatomy of the South American Woolly Monkey (*Lagothrix*). Part 1. The Forelimb.

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(Plates I-V).

Introduction.

In presenting this description of the gross anatomy of the forelimb of *Lagothrix*, the South American woolly monkey, it should be explained that subsequent papers are planned to cover the entire body. These will consist of appropriate regional divisions, designed, so far as possible, to permit ready integration.

Rather than employing the standard, systematic method, I have chosen the regional or "dissector's manual" type of description. In my opinion this is the only logical way to present the material in a form that is readily usable for practical purposes. Functional interpretations will be omitted except in those parts where the anatomical details revealed in the dissection seem to lend themselves particularly to the emphasis of certain points, or where the functional aspect appears to require an especial annotation underlining the conclusions I have reached.

The anatomical material on which this description is based consists of one adult female, one young female, and one male infant. The first two are *L. lagotricha*, the third *L. cana*. I am indebted to Dr. L. J. Goss, veterinarian of the New York Zoological Park, for his great courtesy and generosity in placing this material at my disposal. Without his help and encouragement much of this work would not have been possible.

A search of the literature has revealed only the most fragmentary data on the genus *Lagothrix*.

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External Characteristics.

The upper extremity in *Lagothrix*, as in all primates, is a remarkably differentiated member capable of a great variety of movements and serving for locomotion, and in particular, prehension which is characteristic of primates. By grasping objects and drawing them near for close visual inspection, and for stereognostic appreciation, the primate is peculiarly favored in a minute and accurate orientation to its environment.

The upper extremity of *Lagothrix* acts simply as a forelimb when the animal is walking on the ground. The hand, with its characteristic position of flexion into a balled fist, carries the weight on the well-developed hypothenar eminence which presents a proximal extension. The flexed fingers may bear some weight as would the toes for very brief periods in man, but the fingers are never extended while the animal is walking on a flat surface, and any weight-bearing by the fingers is on the dorsal surface of the distal phalanges of the flexed digits. This is of interest as it may represent a stage in the development of the digital posture of the anthropoid hand.

Lagothrix is not usually thought to be a brachiator, but some authors have mentioned observations of the occasional use of this method of progression. I have frequently observed genuine brachiation, although it must be admitted that it is modified by the constant use of the prehensile tail for temporary support as well as maintenance of balance. This is in contrast to *Ateles* which frequently brachiates without employing its tail for support, and of course to the anthropoid apes which lack a tail. The forelimb is very important in climbing and in supporting its share of the weight in the four-legged type of progression erect or inverted.

The hand presents its most specialized prehensile activities, however, when the position of the animal, such as sitting on its haunches, standing erect on the hinder extremities, or hanging supported by them and the tail, frees the arms for this purpose. The grasp, as discussed elsewhere, is of two general kinds—one a simple haphazard and hasty grasp, the other more elaborate and directed toward exact approach to the object.

Integument.

The skin of the forelimb is thickly covered with the thick rabbit fur-like hair characteristic of this genus for which the name was given. As a general rule, all species or types show a tendency to a predominance of darker hair from the elbows distally. The hair is dense on the extensor surfaces. It is thinner and sparse on the flexor surfaces, presenting bare spaces in the axillae about the nipple, in the supraclavicular region and in the antecubital fossa. Elsewhere it is thick and dense. Adults of all types present along the anterior border of the limb a thick fringe of long hair, often of great length. On viewing the animal anteriorly, this is seen to be the upper arm of a chiasmal growth that runs down the mid-ventral region and extends along the upper and lower extremities at the cephalic borders. The skin is everywhere freely movable. It is thin and less elastic on the flexor surfaces and thicker and more turgid on the extensor aspect.

The integument of the palm displays the characteristic ridges and grooves, assembled in configurational systems, comprising the patterns of the volar pads and the intermediate and surrounding areas in which there is no definitive arrangement. The variability and diversity of pattern configuration and distribution is such that, like man, no two individuals present identical arrangements. In some twelve pairs of hands I have thus far examined, no repetitions have been found.

The generalized plan of volar pads, as exemplified by the chiridia of the lower mammals, has been materially modified, although remnants of each of the general classifications described by Whipple (4) may be found, varying from one individual to another. The apical pads on the tips of the fingers are comparatively constant and show a monotonous similarity of concentric rings, varying to some degree in the minutiae. Pads on the middle and proximal phalanx show a somewhat greater degree of diversity and variation although they too present little of the specialized diversifications of the palmar pads proper. If one can accept the thesis that the elaboration of the patterns is correlated in some degree with the role of these areas in tactile sensibility and hence with perceptual accuracy, it is suggested that the palmar surface of the proximal phalanges and the opposing surface of the palm constitute the chief areas of perception in this monkey. The interdigital pads in the hands examined are occasionally absent, or much reduced (one specimen), but in all the others there were at least two and in some cases three. These consist of numbers I and II and occasionally III (Whipple's generalized schema). In both hands of one specimen there are intermediate pads with patterns of concentric rings. These are sufficiently well organized and discrete to be considered as probably independent developments and not due to segregation by the superimposed creases, of areas formerly included with the interdigital pads. The thenar and hypothenar areas present well-developed pads, although in none of the specimens I have examined do these pads present significant arrangement of ridges and sulci into concentric rings or whorl-like patterns. They consist, then, simply of open fields, but contrary to the statement of Bychowska, (2) I do not find, except in one specimen, that the lines are directed proximo-distally; on the contrary the direction in all cases is from side to side. This might be expected in view of the importance of these areas, especially the large hypothenar pad, in weight bearing when the animal walks on all fours. The transverse direction naturally increases the frictional resistance, also thought to be an important function of these ridges by some observers. I do not find the areas on the palmar surface proper in which epidermic warts rather than ridges are found by Whipple. In all my specimens the intervening areas between patterns are covered by skin bearing well-developed ridges and at the margins of the palmar area, the ridges simply fade out into non-sculptured skin with no transition in the form of wart-like structures.

The hand of *Lagothrix* has been well described by Pocock (5) as *zygodactylous*. That is, the space between digits two and three is much wider than that between one and two, and the grasp, especially of small elongated objects, is between digits two and three. The thumb should not be disregarded in this connection, however, since, while it moves with the index and the two digits constitute what I call the "thumb unit," it is capable of a considerable degree of independent motility, especially when the index is fixed. There appear to be two possible explanations for this development of a thumb unit consisting of digits one and two; first, that this zygodactylous separation is directed by the same forces that have determined the development or persistence of the cloven hoof of digitigrade quadrupeds; or, second, that this functional division simply represents an individual specialization emphasizing the importance of the index in the absence of independent functional potentialities of the pollex which is incapable of opposition, and is here simply a satellite of the index. It must be considered also that a combination of factors is operative here since in these monkeys

the hand serves a dual function, that of support in the suspended position or in walking on all fours, and also serves to grasp movable objects of various sizes. In the one case strength and stability of structure are essential, while in the other delicacy of motion with graded approaches and refinements of manipulative power are required. At this stage I am not prepared to discuss the importance of the respective factors.

Subcutaneous Tissues and Cutaneous Nerves—Fasciae.

On removing the skin the loose areolar tissue forming the superficial fascia is revealed. There is rarely an appreciable amount of fatty tissue, hence care must be exercised in removing the skin to preserve the superficial sensory nerves. Except for the area of their terminal distribution these run beneath the deep fascia. The deep fascia is not so well defined as it is over the forearm structures. This is especially true around the shoulder region and the upper part of the arm. About the elbow and from there distally, however, the deep fascia forms a well-defined sheet of considerable strength.

The *Nn. supraclaviculares* will be described in detail with the cervical plexus. Two of these emerge in the region of the acromion to supply the skin of the supraclavicular fossa and the superior aspect of the shoulder. The anterior aspect of the shoulder over the deltoid muscle is supplied by a branch of the *N. dorsalis scapulae* that emerges between the deltoid and pectoralis major in the groove containing the cephalic vein. The medial aspect of the arm is supplied by the medial brachial cutaneous nerve whose rami perforate the deep fascia serially. The branches of the medial antibrachial cutaneous nerves spread out in fan-shaped manner over a triangular area on the medial aspect of the forearm, the most distal continuing almost to the wrist. The intermediate antibrachial cutaneous nerves may be more conveniently described later. The lateral brachial branches of the *N. radialis* emerge in the lower half of the arm in the region of the lateral intermuscular septum. These branches supply the lateral aspect of the lower third of the arm and the elbow region. The lateral antibrachial cutaneous nerve consists of three branches supplying an elongated triangular area of the lateral and dorsal aspect of the forearm. The posterior aspect of the shoulder and arm are supplied by cutaneous branches of the *N. axillaris* which emerge from the lower border of the spinous division of the *M. deltoideus*.

The superficial veins of the hand and forearm form two main trunks, the cephalic and basilic, which are formed on the lateral and medial aspects of the wrist by the union of variable veins draining the fingers and dorsum of the hand. There is no dorsal arch and these venous channels from the hand arise from the first and second and from the fifth digits only. The cephalic vein passes upward along the dorsolateral aspect of the forearm and the arm passing medially over the superior border of the *M. pectoralis major* and behind its clavicular origin to join the *Vv. brachiales*. The basilic vein passes upward over the medial and volar aspect of the arm to the antecubital fossa where it pierces the fascia to join the *Vv. brachiales* at this point.

Anterior Thoracic Region.

The fascia of the anterior thoracic region is irregular in thickness, being less restrictive over the main area of the pectoral region. It becomes better defined near the lateral margin of the *M. pectoralis major* at its lower border. This fascia forms a definite diaphragm between the *M. latissimus dorsi*, the *M. pectoralis major* and the fascia of the arm in the axilla. On each side of the midline the fascia is pierced serially by the anterior cutaneous branches of the intercostal nerves. and in the mid-axillary line by their lateral divisions. The fascia is attached firmly to the clavical superiorly and along a median raphe the entire length of the sternum.

The *M. pectoralis major* arises, as in other monkeys, from a median raphe with interlacing fibers crossing the midline from the entire length of the manubrium and corpus sterni, the sternoclavicular joint and the medial third of the clavicle. The upper margin of the lateral third of the pectoralis major lies beneath the lower margin of the deltoid. On separating the deltoid from the pectoralis major the origin of the latter from the inner third of the clavicle and the course of these superior fibers which insert at the lowest point on the humerus are better revealed. When the pectoralis major is severed from its sternal origin and reflected, the inferior portion is found to arise in two sheets, the superficial from the sternum and median abdominal raphe, the deep from the costal cartilage of the sixth rib. These lower fibers take a progressively deeper position as they proceed to the insertion at the highest point on the lateral lip of the bicipital groove of the humerus. When the pectoralis major is turned upward the anterior thoracic nerves and an artery are seen entering its deep surface. This neurovascular bundle passes between the pectoralis minor and the pectoralis abdominis.

A small accessory pectoral muscle which

may be called the *M. pectoralis accessorius* in the absence of other identification, has been found in these specimens. It arises variably from the deep fascia of the abdomen or from the sixth or seventh rib lateral to the lower border of the pectoralis major, and passes behind the major in the midclavicular line to insert with it by a fine aponeurotic tendon on the under surface of the pectoralis tendon. Its functional significance is obscure. A fine branch of the anterior thoracic nerve passes downward to it from the rami supplying the pectoralis major. [1]

The *M. pectoralis minor* arises superficially from the costal cartilages of the third, fourth and fifth ribs, the individual parts being separated by perforating branches of the intercostal arteries and nerves. On reflecting this superficial sheet a deep origin is revealed. This is formed by separate slips of aponeurotic structure from the third, fourth and fifth costal cartilages at a point lateral to the origins of the superficial sheet. There is a third and still deeper origin from the costal cartilage of the second rib. These three sheets are easily separable up to their point of fusion, just short of the insertion by an aponeurotic tendon which the M. pectoralis minor shares with the pectoralis abdominis, covering and attaching to the lesser tuberosity of the humerus. The pectoralis minor is supplied by its own artery and nerve from the anterior thoracic and thoracoacromial group.

The *M. pectoralis abdominis* arises by both a deep and a superficial head. The former lies directly under the latter as they arise from the seventh rib and from the sheath of the rectus abdominis. At mid distance from their origin these two heads diverge, the superficial being inserted more distally than the deep, which occupies an intermediate position between the former and the pectoralis minor, on a thin common tendon of insertion. This covers the lesser tuberosity of the humerus, lying superficial to the insertion of the subscapularis.

When the superior and deep head of the pectoralis minor are reflected, the origin of the subclavius muscle on the costal cartilage of the first rib is revealed. Lateral to the origin of the subclavius is found the upper head of a segmented muscle arising from the first, second, third and fourth ribs in the midclavicular line, each slip giving rise to a thin, flat aponeurosis superimposed one on the other to fuse with the origins of the pectoralis minor on the costal cartilage of the fifth rib. Beneath its termination the uppermost origin of the rectus abdominis from the fourth costal cartilage can be seen. This muscle is only revealed in its full extent in the dissection of the thoracic wall and will receive further consideration in that section.

Separation of the anterior margin of the deltoid from the pectoralis major reveals that, except for about a centimeter of its length, the insertion of the pectoralis major is covered by the deltoid. The two muscles diverge near the clavicle and a bare area of this bone in its middle third is revealed.

The *M. deltoideus* has a lengthy linear origin, and according to the various points may be divided into clavicular, acromial and scapular (spinous) parts. The clavicular origin is from the lateral third of this bone, separated by a distinct interval from the clavicular origin of the pectoralis major. This hiatus of the muscles leaves the bare area described above. The clavicular fibers sweep downward over the insertion of the pectoralis major, with the deeper fibers forming an aponeurotic tendon which fuses in part with the tendon of the pectoralis major. The acromial origin occupies the full curve of this prominence, and these fibers proceed straight downward to insert on the lowest point of the deltoid crest of the humerus. The scapular origin consists of a thin triangular sheet with a concave lower margin arising in part from the lateral two-thirds of the inferior margin of the spine of the scapula and in part by a thin membranous aponeurosis from the lower third of the vertebral margin of the scapula. These lower fibers sweep laterally and converge downward to join the acromial division, inserting posteriorly on the humerus. The deltoid is supplied by the *N. axillaris* which is spread over its deep surface in fan-shaped manner. The nerve is accompanied by the terminal muscular branches of the posterior circumflex humeral artery.

If the deltoid is severed near its origin and reflected downward, the insertion of the pectoralis major is found to fuse in part with the insertion of the anterior fibers of the deltoid. The superior portion of this conjoint tendon forms a tunnel through which the tendon of the long head of the biceps passes from its intra-articular origin to insert on the supraglenoid tubercle.

The axillary fossa is pyramidal in shape with the base presenting laterally. The pectoral muscles together with the common origin of the coracobrachialis and the short head of the biceps form the anterior covering of the fossa. Posteriorly it is bounded by the *M. subscapularis*,

[1] This muscle may be the sole persistent representation of the *M. panniculus carnosus*. Its insertion with the pectoralis major speaks for this explanation (see Hartman & Straus, p. 103), although its origin suggests that it is a part of the pectoralis complex.

medially by the chest wall, and laterally by the axillary fascia. On removing the axillary fascia and the pectoral muscles the axillary neurovascular bundle is revealed. The first third of the axillary artery is bounded below by the axillary vein and posteriorly by the combined cords of the brachial plexus. The middle third of the artery lies behind the cords of the plexus and continues in this position in its distal third. The axillary vein lies first below the artery and nerves and then passes behind the nerves to occupy a position medial to the axillary artery just before it becomes the brachial artery. The first branch of the axillary artery in the axilla is the *A. thoracoacromialis*. This dvides into pectoral branches to the Mm. pectoralis major, minor and abdominis, and gives deltoid and acromial branches to the clavicular and acromial origins of the deltoid. Proximal to the origin of thoracoacromial artery, the medial cord of the brachial plexus gives off muscular branches to the pectoral group and to the subclavius. From the thoracoacromial trunk three arteries constitute its terminal branches; these are the *A. thoracalis suprema,* the *A. thoracalis lateralis* to the serratus anterior, and the *A. thoracodorsalis* supplying the latissimus dorsi. The latter is accompanied by the *N. thoracodorsalis*. The long thoracic nerve passes to the serratus anterior somewhat posterior to the region of the muscle to which the *A. thoracalis lateralis* is supplied. *Note*: To display the brachial plexus in its entire extent it is necessary to disarticulate the clavicle from its sternal attachment and reflect certain structures having attachments in this region. Since this necessitates disturbing these parts, they will be described here.

The *M. sternocleidomastoideus* separates into two distinct bellies in the lower part of the neck. The lateral one inserts on the upper and posterior surface of the medial third of the clavicle. The medial head passes anterior to the sternoclavicular joint and inserts on the superior and anterior aspect of the manubrium sterni posterior to the upper fibers of origin of the pectoralis major. When the lateral head of the sternocleidomastoid is reflected from its clavicular insertion the sternoclavicular joint is revealed.

The *articulatio sternoclavicularis* is a typical diarthrosis with an articular disc of fibro-cartilage. The capsule is loose and permits comparatively free movement. The ligaments consist of the anterior and posterior sternoclavicular ligaments passing in an oblique manner laterally from the sternum. The posterior is several times stouter than the anterior ligament. There is also a costoclavicular ligament between the clavicle just distal to the joint and the superior margin of the first costal cartilage.

By severing the ligaments and releasing the joint, and by severing the *M. subclavius* just beyond its stout origin on the anterior surface of the first costal cartilage and superior surface of the first rib, the clavicle may be displaced and the entire brachial plexus is revealed. Passing over the superior belly of the *M. sternocostalis* is the axillary vein and above it is the axillary artery, lying here on the insertion of the *M. scalenus anterior*. Here the axillary also comes into relation with the upper surface of the arch of the first rib. Prominent in this region is the *V. jugularis externa* passing downward to join the *V. jugularis interna*. The *N. phrenicus* crosses over the subclavian artery to enter the mediastinum just lateral to the *A. cervicalis ascendens*. This latter divides into the *A. transversas scapulae* and continues on as the ascending cervical. The transverse scapular artery gives a branch to the lateral head of the *M. sternocleidomastoideus,* and then passes posteriorly to the superior border of the scapula where it divides into superficial and deep branches. Its further course will be described with that region.

The *M. subclavius* is a very stout muscle in *Lagothrix*. It passes upward and laterally from its origin on the costal cartilage of the first rib, behind the clavicle, to insert on the postero-inferior surface of that bone near the attachment of the acromio-clavicular ligament. A second part of the muscle diverges and passing posteriorly inserts on the superior border of the scapula near the base of the coracoid process.

The Brachial Plexus.

The fifth, sixth, seventh, and eighth cervical and the first thoracic nerves form the brachial plexus. These divide into anterior and posterior divisions, which in turn form the lateral, medial and posterior cords by reunion. Union of the anterior divisions of the fifth and sixth nerves forms the lateral cord, while the medial cord is formed by the union of the anterior divisions of the seventh and eighth nerves, and the posterior cord by the union of the posterior divisions of the fifth, sixth, seventh and eighth nerves. The fourth cervical nerve contributes to the brachial plexus solely by the branch which joins the rami of the fifth and sixth nerves to form the *N. phrenicus*.

The first branch of the lateral cord is the *N. suprascapularis* which consists of the major part of the fibers of the fifth cervical nerve. This passes laterally and posteriorly over the superior margin of

the scapula medial to the insertion of the *M. subclavius* and beneath the *M. supraspinatus*.

Next the lateral cord gives off in succession the ramus of the fifth cervical root to the *N. phrenicus*, and a ramus which joins with a branch of one from the medial cord to form the anterior thoracic nerve to the pectoralis major; the second branch of this ramus from the medial cord passes to the pectoralis minor.

Soon the lateral cord terminates in the *N. musculocutaneus* and in the lateral head of the *N. medianus*. In some specimens this lateral head may receive a contribution from the medial cord before the junction of the medial head itself.

The medial cord may consist of a well-fused mass from the anterior divisions of the seventh and eighth nerves, or these two may combine only at a point somewhat proximal to the formation of the medial head of the *N. medianus*. In the latter case it is clear that the contribution to the anterior thoracic nerves comes from the eighth cervical and that the latter also gives off the medial brachial cutaneous, the medial antibrachial cutaneous, and the intermediate antibrachial cutaneous nerves. The terminal branches of the medial cord are the medial head of the *N. medianus* and the *N. ulnaris*.

The posterior cord like the median cord may form a group of loosely joined plexiform branches with only a small part of its extent forming a true cord. It must be admitted that the separation effected by dissection is often artificial, but it serves to define more accurately the representation of the cervical segments in the final common pathway. The first branch of the posterior cord is the *N. thoracalis lateralis* which arises from the sixth cervical nerve near its spinal exit, and passes inferiorly through some of the heads of origin of the *M. scalenus anterior* to emerge near the anterior border of this muscle and pass obliquely downward and posteriorly over the *M. serratus anterior*, terminating in its individual heads by segmental branches.

The posterior cord gives off a series of subscapular branches to the muscle of that name. Those supplying the more posterior heads come from the fifth cervical, the next from the sixth, while those nearest the anterior border of the scapula are clearly derived from the seventh cervical nerve.

The *N. axillaris* is formed by the posterior divisions of the fifth, sixth, and seventh cervical nerves. The remaining branches of the various contributions enter into the formation of the *N. radialis*. From the medial (eighth cervical) contribution, the *N. thoracodorsalis* to the *M. latissimus dorsi* passes downward and laterally to distribute itself over the inner surface of the muscle. Near its exit from the axilla, the *N. radialis* gives off the muscular branch to the epitrochlearis and a ramus which joins the ulnar nerve and passes distally in its sheath to the mid portion of the arm where it passes to the deep-lying medial head of the triceps.

On the right side the fifth cervical nerve contributes to the phrenic nerve with a ramus as large as that forming its source from the fourth cervical nerve. The ramus from the fifth receives a slender branch from the cervical sympathetic trunk and in addition gives off the motor branch to the *M. subclavius*. It then curves anteriorly over the *M. scalenus* anterior to join the phrenic trunk.

On the left side the phrenic nerve receives contributions from the fifth and sixth cervical nerves as well as from the fourth. The nerve to the subclavius likewise arises on the left side from the fifth cervical root of the phrenic nerve.

Returning to structures about the shoulder joint, anteriorly the common origins of the *Mm. coracobrachialis* and *biceps brachii, caput breve*, superimposed on each other, form a stout tendinous band passing obliquely into the medial aspect of the arm. When this common tendon is severed and reflected, the *N. musculocutaneus* is found along the posterior surface, giving branches to the *M. coracobrachialis* in this region. From the deep surface of the coracoid process beneath the *M. coracobrachialis*, a thin, flat muscle arises and passes laterally to insert on the anteromedial surface of the neck of the humerus just above the insertion of the latissimus dorsi on the medial lip of the bicipital groove. This muscle is supplied by a slender branch of the anterior humeral circumflex artery, which curves laterally below its insertion, and it is innervated by a branch of the musculocutaneus nerve. Hartman & Straus (7) call this muscle the *M. coracobrachialis profunda* in the rhesus monkey but its separate and distinct course in my opinion makes it worthy of distinctive designation. I have called it the *M. coracohumeralis*.

In the region about the shoulder joint the combined tendon of the latissimus dorsi and dorso-epitrochlear muscles lies distally and deep to the coracobrachialis. These two muscles join at an acute angle in the posterior part of the axilla to form the broad, flat tendon which inserts on the superior part of the medial lip of the bicipital groove anterior to the insertion of the teres major. The latter occupies a position posterior to the former along the entire length of the medial lip. Between these tendons there is a large bursa.

In the bicipital groove the prominent rounded tendon of the long head of the biceps is seen passing inferiorly to pierce the capsule of the shoulder joint from its origin on the supraglenoid tubercle. When the short head of the biceps is reflected with the coracobrachialis the origin of the anterior humeral circumflex artery is revealed arising from the axillary artery near the inferior border of the coracobrachialis. It passes beneath this muscle and the musculocutaneus nerve to give branches to the distal part of the pectoralis major and to the *M. coracohumeralis*. A recurrent branch passes to the subdeltoid area of the capsule of the shoulder joint and anastomoses with branches of the posterior humeral circumflex and acromial branches of the thoracoacromial arteries.

The pectoral group of muscles is evidently quite variable and inconstant. In a full grown female (*L. lagotricha*) the pectoralis major arises from the inner third of the clavicle, from the sternum down to the end of the gladiolus and from the seventh costal cartilage. There are no fibers extending from the sheath of the rectus abdominis. The accessory pectoral muscle arises by two heads from the sixth and seventh costal cartilages, the superficial somewhat lateral to the deep head. The two combine near their mid portions and become narrow and rounded. Beyond this point the muscle becomes flattened and fan-shaped. It passes behind the lower border of the pectoralis major and the fan-shaped insertion joins with that of the latter near its superior part. The pectoralis minor arises from inferior, deep and superficial heads. The first takes origin from the sixth costal cartilage. The latter two from the third, fourth, fifth and sixth costal cartilages. All of these joint to insert in a common tendon on the lesser tuberosity. In this specimen there is no muscle which can properly be identified as the pectoralis abdominis.

Posterior Thoracic Region.

The *M. atlantoscapularis superficialis* runs obliquely from the atlas to insert on the lateral extremity of the spine of the scapula near the base of the acromion and covers the acromial insertion of the trapezius.

The *M. trapezius* has a broad transverse origin from a horizontal line on the occipital bone and from the spinous processes of cervical vertebrae by direct, fleshy bundles. At the level of the lower cervical vertebrae the muscle bellies retreat laterally, giving place to a triangular aponeurosis which extends down to about the fourth thoracic vertebra. From that point to the end it arises again directly from the vertebral spines and interspinous ligaments. The cervical portion is inserted on the superior surface of the outer third of the clavicle, on the acromion, and the entire length of the scapular spine. The lower portion inserts only on the inferior margin of the medial third of the scapular spine.

Inferior to the trapezius the posterior attachments of the deltoid are observed to consist of the posterior part of the acromial section and the spinal division which have been described.

On reflecting the trapezius from the vert bral origins the *M. rhomboideus capitis* is revealed. This muscle originates by two heads. The medial head arises from the occipital bone below the origin of the trapezius and from the nuchal ligament, while the lateral head arises by a fan-shaped origin from the occipital bone beneath the origin of the trapezius. These two heads merge to form a wedge-shaped muscle which inserts on the upper third of the vertebral margin of the scapula near the superior angle.

The *M. rhomboideus cervicis* arises from the spines of the cervical vertebrae and is inserted along the vertebral margin of the scapula just inferior to the insertion of the rhomboideus capitis.

The *M. rhomboideus dorsi* arises from the first four or five thoracic spines and is inserted along the vertebral margin of the scapula down to the inferior angle.

The *M. atlantoscapularis posterior* which is revealed on a deeper plane when the trapezius is reflected laterally, arises from the transverse process of the atlas and passes downward and posteriorly to insert on the posterior superior scapular angle, lateral to the insertion of the rhomboideus capitis.

When the fat, areolar tissue and the deep chain of cervical lymph nodes are removed from beneath the trapezius, the *A. transversa scapulae* is observed passing posteriorly and laterally. After crossing the superior margin of the scapula the artery gives off a long muscular branch to the trapezius and a superficial and deep branch to the *M. supraspinatus*. There is also a contribution to the periarticular anastomotic rete over the shoulder joint.

The reflection of the trapezius reveals the origin and main body of the *M. supraspinatus* which takes origin from and occupies the entire supraspinous fossa. Crossing its surface is the superficial branch of the transverse scapular artery which gives off muscular branches here and continues downward to anastomose with the terminal branches of the posterior circumflex humeral artery. The deep branch of this artery passes beneath the supraspinatus, emerging at its lower border beneath the coracoclavicular ligament to contribute its acromial branches to the rete acromiale. From there

the artery continues on as the *A. transversa scapulae profunda* beneath the root of the acromion, where it enters the infraspinous fossa to supply the *M. infraspinatus* and the *M. teres minor*. It is accompanied by the *N. dorsalis scapulae* which supplies the *Mm. supraspinatus* and *infraspinatus*. The *M. teres minor* is supplied by the *N. axillaris*. This ramus enters the muscle near its insertion. The *M. supraspinatus* forms a well-defined tendon which inserts at the highest point on the greater tuberosity of the humerus.

In the infraspinous fossa lie the bellies of the *M. infraspinatus* and the *M. teres minor*. Passing over them superficially is the aponeurotic (origin of the long head of the *M. triceps*) from the spine of the scapula. Medial to the long head of the triceps, the terminal muscular branches of the posterior humeral circumflex artery emerge from between the teres major and minor, ending in the teres major, minor, and infraspinatus. Lateral to the long head of the triceps, the deltoid branches of the posterior circumflex artery emerge with the axillary nerve.

By reflecting the latissimus dorsi, after severing it near its insertion, the inferior angle of the scapula is revealed. Three muscles converge here: The teres major arises from this angle and the entire length of the axillary margin of the scapula. The lower bellies of the *M. serratus anterior* insert on the inferior angle. The lower fibers of the *M. rhomboideus dorsi* from the mid-thoracic spines pass superiorly to insert near the angle.

The major part of the infraspinous fossa is occupied by the *M. infraspinatus* but it shares this area with the *M. teres minor*. The latter is flattened from above downward near its origin, but becomes flattened from before backward so that the fibers having the deepest origin are inserted at a higher point on the greater tuberosity. This insertion is directly below that of the *M. infraspinatus*.

When the rhomboid muscles are severed from their origins and reflected, the descending branch of the transverse scapular artery is found passing downward on the deep surfaces of the rhomboideus capitis and cervicis. The artery continues its course inferiorly and contributes to the anastomoses along the vertebral margin of the scapula.

The *M. splenius capitis* arises from the external occipital protuberance and nuchal ligament to the first or second thoracic spine. Overlying the lower part of this origin is the thin aponeurotic sheet of origin of the serratus posterior superior. Fleshy muscle bundles of the latter, three or four in number, appear beyond the margin of the epaxial musculature and insert on the corresponding ribs. The insertion of the splenius capitis is on the superior nuchal line laterally as far as the mastoid process.

There is a prominent representation of the levator scapulae complex which arises from the transverse processes of the cervical vertebrae and inserts on the superior margin of the scapula to the superior angle, occupying a space between the insertion of the *M. atlantoscapularis posterior* and the upper insertion of the *M. serratus anterior* and *M. rhomboideus capitis*.

Medial and Anterior Aspect of the Arm.

As the deep fascia is removed, the branches of the medial brachial cutaneous and medial antibrachial cutaneous nerves are revealed. The latter continues downward in the groove between the biceps and dorso-epitrochlearis to emerge near the antecubital fossa. These have been observed in the axillary fossa arising by a common trunk with the anterior thoracic nerves from the medial cord of the plexus. The intermediate antibrachial cutaneous nerve, also a branch of the medial cord, runs along the medial border of the short head of the biceps, crosses under the lacertus fibrosus and continues down the middle of the volar surface of the forearm to the wrist.

When the short head of the biceps is separated from the dorso-epitrochlearis and reflected laterally, the neurovascular bundle of the arm is exposed. The *A. brachialis* occupies the following positions with respect to the median nerve which may be taken as a point of reference: The artery and vein lie lateral to the median nerve in the upper third of the arm. At its middle third the artery passes behind the nerve. Just before this occurs the *A. profunda brachii* arises and passes posteriorly in company with the *N. radialis*. The latter has occupied a position posterior to the artery up to this point. The *A. nutricia humeri* arises from the *A. brachii* in its upper third just below the *A. profunda brachii*. The brachial artery in the lower third of the arm lies medial to the median nerve and posterior to the brachial vein. In the arm the brachial artery gives off muscular branches to the long and short heads of the biceps, to the brachialis, the *A. profunda brachii*, and terminates in the antecubital fossa by dividing into the *A. radialis* and *A. ulnaris*.

Curving laterally beneath the short head of the biceps, and becoming then for the first time clearly separated from it, the coracobrachialis is found to insert on the anterior and medial aspect of the humerus between the origins of the brachialis and the medial head of the triceps. The coracobrachialis is supplied by the *N. musculocutaneus* which curves around it laterally or pierces the insertion, giving off muscular branches to both heads of the biceps at this level and continuing medially and distally

to the middle third of the arm where it is joined by a branch of the median nerve. This combined trunk supplies the lower part of the *M. brachialis* and continues to the lateral side of the long head of the biceps where it pierces the deep fascia of the lower third of the arm to supply the skin in this region and in the antecubital fossa. The median nerve likewise gives off a stout branch in the middle third of the arm which passes laterally beneath the biceps to reach the antecubital fossa. This branch continues down the volar surface of the forearm to the wrist as the anterior antibrachial nerve—it usually branches into two parallel rami in the forearm.

On reflecting the brachial artery and vein and the median nerve laterally the entire course of the ulnar nerve to the elbow is exposed. This lies first medial to the vein, then behind it, lying beside the radial nerve to the point where the latter passes posteriorly with the *A. profunda brachii.* From that point it lies on the anterior border of the medial head of the triceps, parallel to the tendon of the dorso-epitrochlearis and passes posteriorly behind the medial epicondyle. The ulnar nerve gives off no branches in the arm.

Lateral and Dorsal Aspect of the Arm.

The muscles presenting on the dorsal and lateral aspect of the arm are the brachialis and triceps. The origin of the former encircles the insertion of the deltoid superiorly and occupies the lateral and anterior aspect of the humerus deep to the biceps. From the curving lower margin of the spinal portion of the deltoid the long and the upper part of the lateral heads emerge and soon fuse. From between the lateral head of the triceps and the brachialis the lateral cutaneous branches of the radial nerve emerge to supply the skin in this region. From between the lateral head of the triceps and the brachialis below, in the supracondylar region additional lateral brachial cutaneous rami appear. Still lower the lateral and dorsal antibrachial cutaneous nerves spread out fanwise over the lateral and dorsal aspect of the upper third of the forearm. The cephalic vein passes superiorly over the brachialis to attain the groove between the deltoid and pectoralis major.

The *M. triceps* may now be described in its entirety. The spinous and infraglenoid origin of the long head have been noted before; the long head fuses with the lateral head on a level with the lowest point of insertion of the deltoid. The lateral head arises from a point inferior to the greater tuberosity of the humerus and on a level with the attachment of the capsule of the shoulder joint. This origin is essentially on the posterior surface of the humerus, by a narrow strip of aponeurotic tendon that is fused with the tendon of insertion of the deltoid. Distally, the origin moves laterally and occupies the middle third of the lateral border of the humerus. It shares the lateral intermuscular septum here with the *M. brachialis.* The medial head in *Lagothrix* is essentially a separate muscle. Its origin begins on the same level as that of the lateral head, but medial to it as far as the medial lip of the bicipital groove. From this point distally it occupies an extensive area on the postero-medial aspect of the humerus almost to the olecranon fossa. It forms a stout tendon which encircles the olecranon and inserts separately and deep to the tendon of the long and lateral heads. The lower portion of this medial tendon is split by a branch of the *A. ulnaris collateralis* (three specimens). Some of the lower muscle bundles arising from the medial supracondylar ridge insert still more deeply on the capsule of the joint posteriorly.

The *Mm. anconeus lateralis* and *medialis* are essentially alike in representing further muscle bundles of the triceps complex. Each arises from the corresponding epicondyle and from the capsule of the elbow joint. They insert on the lateral and medial borders of the ulna respectively. These muscles form the superficial covering of the tunnel through which the *Aa. recurrens ulnaris* and *radialis* pass to join the anastomotic rete about the elbow joint.

The triceps complex is supplied by the *N. radialis* and the *A. profunda brachii.* The two bear important relationships to the triceps. At the junction of the upper and middle thirds of the arm, the artery and nerve pass posteriorly between the long and medial heads of the triceps. The radial nerve has already given off rami to the *M. dorsopitrochlearis* and to the long and lateral heads. In the intermuscular canal the *A. profunda brachii* gives muscular branches to the triceps and to the dorso-epitrochlearis; somewhat lower, the *A. collateralis radialis* arises. This latter emerges from the lower border of the lateral head of the triceps and passes distally to join the anastomotic rete about the elbow joint.

In the middle third of the arm the radial nerve and profunda brachii lie in the radial groove of the humerus in direct contact with the bone and covered here by the conjoint bellies of the long and lateral heads of the triceps. In the lower third of the arm, the *N. radialis* approaches the surface in the angle formed by the divergence of the lateral head of the triceps and the *M. brachialis.* For a distance of a centimeter or so the *N. radialis* is exposed in this lateral area, lying parallel to the border of the brachialis. It then plunges deeply once more beneath the origin of the *M. brachioradialis* to enter the forearm. The lateral antibrachial cuta-

neous and dorsal antibrachial cutaneous nerves are given off in this area.

The insertion of the *M. dorsoepitrochlearis* is on the medial aspect of the base of the olecranon process. In addition to extending the forearm, it is clear that this muscle will assist the biceps in supinating the forearm.

The Forearm.

On removing the integument, the forearm is seen to be sheathed in a stout fascial sheath having strong attachments to the bony prominences of the humeral epicondyles, the olecranon and the borders of the subcutaneous surface of the ulna. There are strong thickenings forming dorsal and volar transverse carpal ligaments.

Just distal to the antecubital fossa, on the medial aspect of the forearm, the prominent *lacertus fibrosus* of the biceps muscle can be traced across the flexor group of muscles almost to the medial border of the ulna, where it fuses with the deep fascia. A short distance proximal to it the medial antibrachial cutaneous nerves pierce the deep fascia and are distributed to the skin over the dorsum of the forearm distal to the olecranon, and to the medial aspect of the forearm for the proximal two-thirds of its length.

Attempts to remove the fascial sheath of the muscles of the forearm reveal the importance of this coat as an origin for some of these and the comparative rigidity of the compartments in which the individual muscles are contained. This is especially true of the flexor group which can be separated only with difficulty from each other since neighboring ones take origin from common intermuscular septa.

When the deep fascia is removed the muscles of the forearm are seen to be divisible into three general groups. First, those which originate on the medial epicondyle of the humerus consisting of the flexors, and held in place by the fascial sheath which is firmly attached to the medial aspect of the subcutaneous surface of the ulna. The second consists of the extensor group of muscles which arise from the lateral epicondyle. Their fascial sheath has its strongest attachment to the lateral aspect of the subcutaneous border of the ulna. The third group consists of a single muscle, the brachioradialis, which has a broad, flat, fleshy origin from the humerus on the upper part of the lateral epicondylar ridge and in part medially from the tendon of insertion of the *M. brachialis*. In the tunnel between these two heads of origin the radial nerve passes into the forearm to join the radial artery and vein.

If the biceps is reflected laterally, the median nerve, and the brachial artery and vein medial to it, are exposed lying on the brachialis tendon. Just proximal to the bifurcation the brachial artery gives off the *A. collateralis ulnaris*. This is a slender branch passing over the medial head of the triceps. It joins the ulnar nerve and passes behind the medial epicondyle to anastomose with the *A. recurrens ulnaris*. Immediately after its origin the *A. radialis* passes laterally across the median nerve and the tendon of the *M. biceps*, joining the radial nerve behind the *M. brachioradialis*. At this point it gives off the *A. recurrens radialis* which turns back at once and passes lateral to the tendon of the biceps and of the brachialis to join the anastomosis about the elbow. The *A. radialis* also gives muscular branches here to the *M. supinator* and to the brachioradialis before continuing distally in the forearm.

In the region of the bifurcation of the brachial artery in the arm, the *A. ulnaris* gives off the *A. collateralis ulnaris inferior* which passes medially under the tendon of the medial head of the triceps, giving off, as it passes, a slender branch to the adjacent origins of the *M. pronator teres*. If the *M. brachialis* is rotated laterally just above the point of formation of its tendon, a bare area of the humerus may be observed; there are no muscular attachments in this region. Here also the median nerve gives off muscular branches to the *M. pronator teres* before passing deeply in the angle formed by the insertion of this muscle on the radius. The tendon of insertion of the *M. brachialis* is partially revealed passing obliquely downward in the antecubital fossa. It is seen to consist of very stout fibers forming a thin knife-like edge with the sharp edge presenting distally and following its oblique course posteriorly to insert on the coronoid process of the ulna. The similarly flattened tendon of the biceps lies in the same sagittal plane, passing to its insertion on the *tuberositas radii*.

The *M. pronator teres* forms the medial boundary of the antecubital fossa. It arises by stout fleshy fibers from the medial epicondyle of the humerus. Its fibers sweep laterally and the upper ones insert on the deep or medial surface of the radius while the lower ones, which arise in part from the medial epicondyle and in part from the intermuscular septum between this muscle and the origin of the *M. flexor carpi radialis*, form a broad, flat aponeurotic tendon which inserts on the lateral border of the curve of the middle third of the radius. On reflecting the origin from the medial epicondyle a stout tendon is revealed lying on the deep surface of the muscle. Extending from a medial position this tendon passes through the mid portion of the muscle to insert on the radius and form a bridge beneath which the ulnar artery and median nerve pass. It should be noted that the lower third of the

medial border of this muscle presents a thin, free margin.

When the pronator teres is reflected, the first part of the ulnar artery and median nerve are revealed. The artery soon joins the nerve and the two proceed distally together in the forearm, deep to the flexor group and parallel to the ulna. In this region there are muscular branches of the median nerve to the flexor muscles.

The *M. flexor carpi radialis* originates from the medial epicondyle and from the intermuscular septa which separate it from the pronator teres laterally and the flexor digitorum sublimis medially. It is a thin rounded muscle which becomes flattened near the wrist and passes laterally to insert on structures of the wrist region to be described with that part. It is innervated by the median nerve.

The *M. flexor digitorum sublimis* occupies the next medial compartment of the flexor group. It has a narrow fleshy origin from the medial epicondyle and a broad flat aponeurotic tendon of origin from the ulna. This latter extends from a region about a centimeter from the olecranon to within an equal distance from the radio-ulnar joint. It is richly supplied by the median nerve and the ulnar artery gives off its muscular branch near the middle of the belly. In the oval hiatus created by the humeral and ulnar origins of this muscle, the muscular branches of the ulnar nerve to the flexor carpi ulnaris pass to that muscle.

When the flexor digitorum sublimis is reflected the humeral origin of the flexor digitorum profundus is observed to be a fleshy bundle which shares a common tendon with the humeral head of the sublimis. The humeral head of the flexor digitorum profundus becomes flattened distally and terminates in a flat tendon which emerges with the principal tendon of its deeper origins.

Relation of Nerves and Arteries to These Structures.

The median nerve lies deep to the humeral head of the flexor digitorum sublimis for most of its length in the forearm, passing laterally in the lower third to occupy a median position beneath the tendon of the flexor carpi radialis. In this region it gives off superficial cutaneous branches to the volar surface of the wrist and proximal part of the palm of the hand.

There are fine branches of the median nerve which pass in recurrent fashion about the ulnar artery at the point where it gives off muscular branches to the flexor digitorum profundus. These run backward proximally to the elbow joint in the region where the ulnar nerve enters the forearm. At the point where these recurrent articular branches turn proximally, the ulnar artery gives off the *A. interossea communis*. This may arise as a single trunk dividing at once into the *Aa. interossea volaris* and *dorsalis*, or these may arise separately from the ulnar artery. Beyond this point the ulnar artery proceeds medially to join the ulnar nerve passing beneath the humeral head of the flexor digitorum profundus. From this point on the artery courses distally to the wrist with the nerve, deep to the ulnar origin of the flexor digitorum sublimis and gives off prominent muscular branches to this muscle at the point of junction with the ulnar nerve.

The *M. flexor carpi ulnaris* is the last superficial muscle of the flexor group. This takes origin from the most posterior part of the medial epicondyle of the humerus and from the major part of the medial border of the subcutaneous surface of the ulna. Its tendon of insertion passes volarward to insert on structures of the wrist which will be described with that region.

The *M. palmaris longus* is a thin and variable muscle, sometimes absent or fused with the flexor carpi ulnaris. It arises from the medial epicondyle and lies superficial to the other flexors. It soon gives rise to a thin, flat tendon that passes over the transverse carpal ligament to insert on the palmar aponeurosis. These two muscles are supplied by the *N. medianus*.

The Extensor Group.

Arising from the lateral supracondylar ridge of the humerus, just below the origin of the brachioradialis, is the thin and narrow *M. extensor carpi radialis longus*. In the middle of the forearm this muscle gives rise to a narrow tendon which pursues a distal course parallel to the next muscle.

The *M. extensor carpi radialis brevis* takes origin by a few fibers from the supracondylar ridge, but in the main from the lateral epicondyle and in part from the intermuscular septum which it shares with the next muscle. While the brevis is a stouter muscle than the longus, its tendon likewise begins in the middle of the forearm. However, bipenniform fibers continue to join this tendon almost to the wrist. It accompanies the longus into the wrist. Both of these muscles are innervated by the radial nerve and supplied by the radial artery.

The *M. extensor digitorum communis* arises by a stout, flat aponeurosis from the lateral epicondyle just posterior to the preceding muscle. It is a narrow muscle sharing the intermuscular septum with the extensor carpi radialis brevis and continues as one muscle almost to the wrist. Just above the dorsal carpal ligament, however, two bellies diverge and give rise to closely compressed bundles of tendons which enter separate compartments of the ligament. The nerve supply is furnished by the *N. radialis*.

The *M. extensor carpi ulnaris* arises from

the posterior aspect of the lateral humeral epicondyle and for a short distance its proximal portion takes origin from the sheet of the deep fascia that binds it to the lateral border of the ulna. This thin narrow muscle runs parallel to the others and the flat tendon passes somewhat medially over the head of the ulna to the medial side of the wrist.

When the origins of the last two muscles are separated, the dorsal interosseus artery is revealed emerging from between the *M. supinator* and the ulnar head of the abductor carpi radialis. This gives muscular branches to the *M. extensor digitorum longus* and the *M. extensor carpi radialis*. Both of the latter muscles are innervated by branches of the *N. radialis* which pierce the ulnar head of the *M. supinator* to reach the dorsum of the forearm. These branches are from the ramus profundus of the radial nerve.

Reflection of the origins of the extensor muscles reveals the extensive origin of the *M. supinator*. This arises by a wide, fleshy and aponeurotic origin from the lateral epicondyle of the humerus and surrounds the radio-humeral articulation on all but its dorsal aspect. It arises in part, also, by a deep head from the upper third of the ulna. The more medial fibers arising from the epicondyle pass in a sagittal direction distally to insert on the medial aspect of the radius. It is likely that these fibers act to flex the forearm. On the mediolateral aspect of the muscle there is a stout tendinous band which passes almost uninterruptedly to the radial insertion. It is beneath this that the ramus profundus of the radial nerve passes to the dorsum. The *M. supinator* is innervated by the radial nerve and supplied by the radial artery.

The deep muscles of the dorsum of the forearm are the abductor carpi radialis and a muscle complex to be described presently. The former arises by a long narrow head from the lateral aspect of the ulna, from a point on a level with the head of the radius for the full extent of the upper third of the ulna. From this point on it verges laterally, taking origin in part from the interosseus membrane and in the middle third of the ulna by an aponeurotic sheet. Fleshy fibers again take origin from the lower third of the ulna almost to its head. The radial head begins narrowly along the border of the insertion of the *M. supinator* and continues distally over the middle third of the radius. Beyond the *M. supinator*, this margin of the muscle is free. The two heads converge on a central tendon which moves laterally to occupy the lateral border of the muscle where it crosses over the *Mm. extensores carpi radialis longus* and *brevis* to enter a compartment of the dorsal ligament of the wrist. Beyond this the tendon passes in its own serous sheath divided into two which insert on the *Ossa multangulum majus* and *minus*. The tendon is crossed in this region by the radial nerve and artery.

The last deep muscle is a complex extensor which arises from the middle third of the ulna along its lateral border lying deep to the extensor carpi ulnaris. Near the wrist this gives rise to two tendons; the lateral passes in a separate compartment in an oblique direction laterally beneath the comparment containing the *M. extensor digitorum communis*. The medial tendon and the tendon bundle of the latter muscle pass through the same compartment. These are the *Mm. extensor indicis proprius* and *extensor pollicis*. Both of these deep muscles are innervated by the ramus profundus of the *N. radialis* and supplied by the *A. interossea dorsalis*.

Extensor Tendons on the Dorsum of the wrist.

The relation of the tendons of the extensor muscles in their respective synovial sheaths as they pass through the dorsal (radio-ulnar) ligament are as follows from the lateral to the medial side:

The tendon of the abductor carpi radialis divides into two distinct tendons proximal to the point of entrance into the carpal sheath. The more lateral of these inserts proximal to the medial one. Its fibers originate entirely from the radius, and while there are mutual insertions of the fibers of the radial and ulnar heads on the tendons of the other, these may be considered as two separate muscles. The tendons enter the common sheath obliquely and course in a groove on the dorsum of the ulnar head. Both insert on carpal bones, the medial and longer tendon curving over to the volar surface of the wrist where it inserts on the *Os multangulum minus*. The proximal tendon inserts on the *Os multangulum majus*.

The *M. abductor carpi radialis* corresponds to the *Mm. abductor pollicis brevis* and *longus* in man. I have chosen to call it the carpal abductor, since it has its principal insertions on the carpus and it is evident that its most important action is to abduct the hand rather than the pollex or the first metacarpal alone. Even though there may be fibers of insertion on the base of the first metacarpal, the strength of the carpal unit insures the movement of the entire mass rather than that of the comparatively weak pollex. It also extends the wrist when the latter is fixed by the extensors and the *M. extensor carpi ulnaris*.

Beneath the tendons of the abductor carpi radialis, the tendons of the extensor carpi radialis longus and brevis pass in their own sheath. As they emerge on the dorsum of the hand they separate from one another, the longus inserting on the carpo-metacarpal joint and on the base of the second meta-

carpal bone. The brevis inserts correspondingly on the third metacarpal bone and the carpo-metacarpal joint.

Crossing over the insertion of the *M. extensor carpi radialis brevis*, two tendons are observed to diverge near the middle of the second metacarpal bone; the lateral one is the tendon of the *M. extensor pollicis*, the medial one is the tendon of the *M. extensor indicis proprius*. Just before the latter passes to the index it sends an extension into the medial aspect of the tendon of the extensor pollicis. On tracing these tendons backward to the proper carpal canal, they are found to arise from the single deep muscle in the forearm arising from the middle third of the ulna. This lies parallel to the extensor muscle that with it occupies the deepest compartment of the dorsal canal. This latter muscle joins the tendon of the extensor digitorum communis.

The tendons of the extensor digitorum communis occupy the central compartment and these are joined on the deep surface by the tendon passing to the index and pollex. This latter divides into three, the lateral joining the under surface of the tendon to the index, the other two proceeding to the third and fourth fingers respectively. The tendon of the extensor digitorum communis itself divides immediately into five divisions which are distributed as follows:

The first passes to the index alone after giving off the connecting band to the tendon of the third finger. The second division passes exclusively to the middle finger. The third straddles the third and fourth, giving tendons to each. The fourth gives a contribution to the fifth in the metacarpal region and then passes directly to the fourth finger. The fifth straddles the fourth and fifth digits, giving tendons to each.

The medial part of the extensor digitorum communis may be considered as a separate muscle although it has a common origin with the communis. However, its belly may be separated almost the entire length of the forearm and it passes through a separate, more medially placed compartment in the wrist. In the carpal region the tendon divides to give a lateral tendon to the fourth finger which passes deep to the tendon of the extensor digitorum communis and a medial one which may be considered as constituting the tendon of the *M. extensor digiti quinti*.

The most medial compartment of the dorsum of the wrist is occupied by the tendon of the extensor carpi ulnaris. This courses medially in an oblique direction in its groove on the head of the ulna to pass volarward and inserts on the volar surface of the base of the fifth metacarpal.

Each common extensor tendon spreads out in a flat sheet over the metacarpophalangeal joint. This sheet is continued over the proximal phalanx and extends volarward with well defined margins on each side about half the thickness of the digit. This sheet inserts laterally on the base of the second phalanx. The central dorsal portion continues as a long triangular extension passing over the dorsum of the second phalanx; its base inserts on the base of the distal phalanx.

The Dorsal Carpal Ligament.

The dorsal (transverse) carpal ligament is exceptionally stout and provides firm restraint for the extensor tendons. There are three major and distinctly separate parts. The first extends from a ridge on the medial side of the base of the radius over the extensor tendons, the head of the ulna, and inserts on the apex of the *Os triquetrum* below the *Os pisiforme*. The second arises from a point distal to the origin of the first, beneath the tendon of the extensor carpi radialis brevis. This ligament extends medially parallel to the first; its insertion is broader than its origin. The proximal attachment is to the head of the ulna and distally it curves about the extensor tendons to form the medial wall of their restraining canal, inserting on the carpus. The third originates on the base of the radius lateral to the tendon of the extensor carpi radialis longus and inserts in part on the lip of the groove in which the tendon of the abductor carpi radialis is confined and continues distally to insert on the *Os multangulum majus*. A fourth component covers the groove in which the tendons of the *Mm. extensor carpi radialis longus* and *brevis* lie.

The divisions of the extensor tendons of the hand have important functional implications. The existence of a separate, common extensor of the pollex and index helps to explain the observation that these two digits act as a joint unit. Further, its ulnar origin and the lateral course of its tendons serve to abduct this thumb unit of the hand from the remainder of the digits. The common extensor of the digits arises from a region that is medial with respect to the origin of this muscle and yet the tendons of both are fixed in the carpal canals at essentially the same point. Thus, when the muscles contract they are exerting their effective pull in essentially opposite directions.

The only hint of functional independence of the remaining digits is that when separated by rough dissection, the muscular bellies of the individual parts are found to originate from progressively dorsal positions on the lateral epicondyle, those of the fourth and fifth fingers become fleshy at a point considerably below the bellies of the bundles going to the second and third fingers. The common origins from intermuscular septa and the firm sheath in which

they are held makes the functional interpretation of these details difficult.

The *Mm. extensor carpi radialis longus* and *brevis* not only extend the hand, but when the latter is in a position of radial deviation, they tend to adduct it in an ulnar direction and bring it into the median axis. The same is true when the hand is in the position of ulnar deviation.

When the principal extensors of the digits are elevated from their canal in the wrist, it is clear that the depth of this passage with the firm bony walls formed by the grooves in the base of the radius and the head of the ulna and the strong ligamentous roof provide fulcra which direct the effective pull of the muscles. Examination of the origins and insertions of the respective muscles makes clear the combined extending and separating action. The extensor digiti quinti takes origin lateral to the median axis of the wrist, but its insertion is well to the medial side of the axis; its tendon passing through the canal is firmly held in the median line and hence abduction of the fifth occurs with extension, when the exclusive motion of this digit effected by the extensor is considered. The origin and insertion of the extensor pollicis and indicis are the direct opposite of the foregoing, but the essential movement is of the same nature, combined extension and abduction.

The interlacing fibers between the tendons to the third and fourth fingers indicate in my opinion a relative interdependence between the motion of extension of these fingers produced by their extensors. That is, extension of one without simultaneous extension of the others would appear to be impossible anatomically. While the axis of effective pull of the extensor indicis proprius points to an independent motion, in association with that of the pollex, the equally strong tendinous contribution from the extensor digitorum communis suggests a beginning transition to an association of the movements of this finger with that of the others opposed to the thumb. The modification of these considerations by the action of the intrinsic muscles of the hands will be discussed elsewhere.

When the extensors are reflected, a long branch of the ramus profundus of the *N. radialis* is revealed on the deep surface of the *M. extensor pollicis* et *indicis* and may be traced to the dorsum of the wrist, the hand and into the wrist joint itself. The terminal branch of the *A. interossea volaris* emerges from the lower margin of the *M. abductor carpi* and anastomoses with the superficial branch of the radial artery and other contributors to the *Rete carpi dorsalis*. The superficial branch of the *A. radialis* which curves dorsally over the base of the radius to gain the dorsum of the hand, passes superficial to the tendons of the *M. extensores carpi radialis longus* and *brevis* and turns medially forming the *Arcus carpi dorsalis*. It continues medially deep to all the extensor tendons and anastomoses with the ramus dorsalis of the *A. ulnaris*. On the dorsum it sends anastomotic rami proximally to the *Rete carpi dorsalis* and at each interspace including the first, gives off *Aa. metacarpi dorsales*. Each of these gives off a digital artery to the corresponding side of the digits and perforating branches which pass between the heads of the metacarpals to anastomose with the volar metacarpal arteries.

Superficial Structures of the Palm.

The skin of the palm is densely attached to the palmar fascia and bound to the first and fifth metacarpal bones and to the volar carpal ligament at the wrist. When this is removed the strong palmar aponeurosis is revealed occupying a central position over the carpus and metacarpal areas. There are extensions of variable strength and prominence reaching the bases of the digits. Arising from the ulnar margin is the *M. palmaris brevis* which passes medially to insert on the skin of the medial border of the palm. It is innervated by the ulnar nerve. The palm is well padded with lobules of fat which are held in firm compartments of fibrous tissue. These pads of fibro-adipose tissue emerge between the four principal extensions of the palmar fascia running to the bases of the second, third, fourth and fifth digits. The pads receive a rich nerve supply from the metacarpal divisions of the nerves of the palm.

When the palmar fascia is severed in the middle of the palm and reflected distally it is seen to be tightly bound to the medial side of he palm by stout projections that insert on the lateral border of the fifth metacarpal and by deep extensions it is firmly bound to the metacarpo-phalangeal joints. Proximally the palmar fascia is fused with the transverse carpal ligament which forms the volar roof of the carpal flexor canal.

Medially, the ulnar artery emerges to give rise to the *Arcus volaris superficialis*. This curves laterally over the palm and is visible between the digitations of the palmar aponeurosis. It gives off *Aa. metacarpi volares*, each of which terminates in the corresponding interspace to give rise to the *Aa. digitales volares propriae*. Emerging with the ulnar artery is the *N. ulnaris* which gives off terminal branches to the lateral side of the fifth digit, the medial side of the fourth digit and after joining with a stout branch of the *N. medianus*, supplies the lateral side of the fourth digit and the medial side of the third digit. It should be noted that the *N. ulnaris* passes in a superficial compartment over the transverse carpal ligament, while the *N. media-*

nus passes through deep to this ligament in company with the flexor tendons. The median nerve supplies in the hand, the lateral side of the thumb by an independent branch, the medial side of the thumb and the lateral side of the index, the medial side of the index and the lateral side of the middle finger and, in conjunction with the ulnar, the medial side of the middle and lateral side of the ring finger. The superficial branch of the *N. ulnaris* passes beneath the ulnar artery and the *Arcus palmaris superficialis* to the lateral side of the fifth finger and medial side of the fourth.

On reflection of the palmar fascia in the proximal part of the palm, the relations of the *N. medianus*, *N. ulnaris* and the *A. ulnaris* are revealed. The superficial branch of the median nerve passes medially over the tendon of the *M. flexor digitorum sublimis* under which it has coursed up to this point. It is joined, beneath the insertion of the *M. flexor carpi ulnaris* on the *Os pisiforme* by the ramus palmaris of the ulnar nerve and the ulnar artery. These enter a compartment beneath the overhanging *Os pisiforme*. Here there are plexiform branches of the median nerve that pass to the ulnar nerve. The ulnar nerve divides to give off a superficial branch which passes to the medial side of the fifth finger and a deep branch which passes dorsally between the *M. abductor digiti quinti* and the *M. flexor digiti quinti brevis*.

The floor is formed by the stout transverse carpal ligament. This has exceedingly strong attachments to the carpus and forms the roof of the deep carpal canal through which the tendons of the flexor muscles pass.

If the transverse carpal ligament is divided longitudinally, the carpal canal and its contents are revealed. The canal is smoothly lined and its thickness and rigidity clearly act as a restraint to the flexor tendons. Lying on the tendons superficially the *N. medianus* is loosely bound to them by loose areolar tissue. This emerges in the palm below the distal border of the transverse carpal ligament and divides to form three metacarpal branches passing to the first, second and third interspaces and corresponding sides of the thumb and fingers. A fourth branch gives off the muscular supply to the *M. flexor pollicis brevis* and continues distally to supply the lateral aspect of the thumb. The most medial branch is joined by a branch of the superficial ramus of the *N. medianus*. It is probable that these plexiform intercommunications have no great functional significance aside from the obvious overlapping representation of important sensory areas.

The *M. flexor digitorum sublimis* tendons in the wrist lie superficial to those of the *M. flexor digitorum profundus*, but in the carpal canal they lie medial to the latter. The flexor sublimis may be reviewed now that it is revealed in its entire length. The four tendons to which it gives rise may be followed proximally into four distinct bellies, but of these latter only that whose tendon passes to the index remains comparatively distinct in its entirety. In the canal the tendon to the index lies deep to the other three and arises from that part of the muscle lying most deeply and constituting the part taking origin from the ulna. However, the pointed upper extremity of the belly joins with the others to take origin from the medial epicondyle of the humerus. The strong flat tendon forms on the lateral aspect of the muscle, the lower fibers of which take origin directly from the ulna. It would seem that these tend to draw the index toward the midline or median axis of the hand when flexing the digit.

The remaining tendons and the bellies from which they derive are as follows: The division for the fifth digit is the most medial and superficial. It takes origin from the strong aponeurotic covering of the muscle which fixes it to the epicondyle. This aponeurosis sweeps medially to attach to the ulna and the lower fibers of this belly arise from it. The intermediate belly takes origin solely from the humeral epicondyle and in its upper part lies superficial to the division going to the middle finger. The latter is a typical bipennate muscle deriving its fibers of origin chiefly from the epicondyle, deep to the last muscle, but in addition receives a sheaf of fibers from the common aponeurotic tendon of this muscle attaching to the ulna. Its fibers pass deep to those of the index division. The tendon comes to lie lateral to those to the fourth and fifth finger. These tendons as they lie in the carpal canal are simply held together by loose areolar tissue. There is apparently no synovial sheath.

When the flexor sublimis is elevated the common tendon of the *M. flexor digitorum profundus* is found to lie in part lateral and in part deep to that of the sublimis. The two separate and distinct bellies of this muscle as seen in the forearm, the one arising from the entire length of the radius and by a deeply lying humeral head, the other arising from the entire length of the ulna, are easily separable from one another. The rami of the *N. medianus* enter the bellies at a point above their juncture in the upper third of the forearm. In the carpal canal, however, the tendons of these two join by a broad union to form a single flat band which immediately divides into five individual tendons. When the tendons are severed in the wrist and displaced distally, the deep surface presents an interesting complexity.

Medially the tendon of the digiti quinti

may be traced directly from the lateral portion of the ulnar division of the muscle, and this may be traced as a separate muscle belly in the forearm lying medial to the others. However, this tendon sends a prominent contribution to the tendon of the fourth finger. The latter is formed of the remaining bundles from the ulnar division and from a stout contribution of the radial muscle. The tendon of the middle finger proceeds directly from the radial muscle, and the fibers of this tendon and that of the index are in part seen to curve posteriorly from the anterior part of the muscle. Thus, the tendon of the pollex is partially sheated in its first portion. It should be pointed out here that there is no tendon of the flexor digitorum sublimis to the thumb.

This interlacing structure of the tendons no doubt serves to reinforce the combined grip of the individual fingers. The flexor profundus may be thought of as a muscle chiefly employed for climbing and hanging suspended, actions which involve all the fingers at once and require none of the refinements of independent motility.

The tendons in the carpal canal are not surrounded by a sheath, and the *Vaginae propriae* of the deep tendons do not begin until the point at which they are joined by the tendons of the *M. flexor sublimis;* both tendons enter a common sheath at this point. The fibers passing to the tendon of the index curve from the antero-lateral aspect of the common tendon, around the tendon of the pollex. The lowest muscle fibers arising from the radius curve medially and posteriorly to be continued as the tendon of the index. Thus, the tendon of the thumb arises from that portion of the muscle lying on the anterior surface toward the mid-line. The tendon of the third finger is derived from that portion of the muscle lying most medially and the fibers may be traced chiefly to the humeral head. The tendon of the fourth finger receives a contribution from the tendon of the fifth, which joins the remaining fibers of the ulnar muscle, and the stout tendon which passes to it from the radial muscle on the deep surface of the tendon mass.

The four *Mm. lumbricales* consist of thin spindle-shaped muscles taking origin from the bifurcation of the tendon of the extensor digitorum profundus and for a short distance from the adjacent sides of these. They lie in the space between these tendons until they reach the metacarpo-phalangeal joints where they enter a canal or sheath formed by extensions of the fascial slips from the digitations of the palmar fascia where it becomes firmly attached to the joint capsule.

Between the heads of the metacarpals there are well-defined intercapitular ligaments consisting of flat sheets blending with the metacarpo-phalangeal joint capsules. These sheets form slings in which the lumbrical muscles rest, separating them from the deeper intrinsic muscles. The lumbricales pass in separate fibrous compartments over the antero-lateral aspect of the metarcarpo-phalangeal joints to insert in each case on the volar border of the extension of the broad tendon of the *M. extensor digitorum communis.* A single exception is the fourth lumbrical which has been found to insert in one case on the lateral aspect of the proximal phalanx of the fifth digit rather than on the adjacent extensor tendon. With the fingers flexed on the palms the lumbricals serve to extend the second phalanx on which this portion of the extensor tendon inserts. The first lumbrical inserting on the index, by reason of its origin well to the medial side of the axis of this finger, will produce some degree of abduction also.

In the middle of the palm the tendons of the flexor digitorum sublimis join the tendons of the flexor digitorum profundus and at this point the sheath of the latter opens and extends deeply to include the two tendons which from that point to their insertions occupy a common sheath. Over the metacarpo-phalangeal joint the sheath presents a circular thickened band which strongly confines the tendons; beyond this the capsule again becomes thin and membranous. Similar annular ligaments are found at each interphalangeal joint. At points between these there are additional annular ligaments near the middle of the proximal and middle phalanges. These correspond to the ligamenta cruciata in man, but in *Lagothrix* they are simple circinate bands which are firmly attached to the borders of the groove in which the tendons lie. Near the middle of the proximal phalanx the overlying tendon of the flexor sublimis divides to permit the tendon of the flexor profundus to emerge and continue its central course to insert on the base of the distal phalanx. It also is divided and the two parts diverge slightly at the point of insertion. The two parts of the flexor sublimis occupy positions on each side of the deep tendon. At the middle of the second phalanx the tendon of the profundus spreads out, partially covering the insertion of the sublimis on the margins of the volar groove of the phalanx in which the tendons lie. The flexor tendons possess well-developed *vincula* passing to their under surfaces from the hollow of the sheath. There is one from the middle of the proximal phalanx to the sublimis tendon at the point of division and a second just proximal to the first interphalangeal joint. A third joins the tendon of the profundus proximal to the second interphalangeal joint.

The tendon of the pollex deriving from radial division of the flexor digitorum profundus passes unaccompanied to the thumb. There are the usual annular ligaments over the joints and a single very stout annular ligament binding the tendon firmly to the distal half of the proximal phalanx. Here, too, the tendon shows the usual division of the deep tendons and inserts similarly on the distal phalanx, but at a point somewhat nearer the distal tip.

Removal of the flexor tendons reveals the first layer of the intrinsic muscles of the hand forming the floor of the palm. The most prominent of these is the fan-shaped *M. adductor pollicis*. This muscle is variable in extent, but occupies roughly half of this region of the palm. It is triangular in shape and consists of four heads of inconstant shape, although the origins and general configuration are readily identified in each case thus far examined. The proximal head takes origin from the carpo-metacarpal ligament at the base of the third metacarpal and courses distally on the upper portion of the common tendon of the muscle. This head also takes origin from a curved tendon whose concavity is directed medially, extending from the carpo-metacarpal ligament to terminate in the joint capsule of the fifth metacarpo-phalangeal joint. The second head takes origin from the convex border of the curved tendon. The third and fourth arise variably from this tendon or from separate tendons, the third from the base of the fifth finger and fourth from the region of the fourth metacarpo-phalangeal joint. The fibers of each converge on the common tendon which is inserted on the medial aspect of the base of the proximal phalanx of the thumb and in part upon the extensor tendon. It is innervated by the ramus profundus of the ulnar nerve as this crosses the palm; the nerve enters the deep surface of the muscle.

When the *M. adductor pollicis* is reflected, a bicapitate muscle is revealed arising from the upper portion of the curved central tendon from which the *M. adductor pollicis* also originates and from the slip that takes origin from the base of the fourth finger, converges on a common tendon which inserts on the medial border of the extensor tendon of the index. This is the *M. adductor indicis proprius*. In some cases it inserts largely on the lateral aspect of the proximal phalanx. In some specimens this muscle is as well developed as the adductor pollicis and consists of stout fleshy bellies arising from the entire length of the central tendon from which the adductor pollicis takes origin. In such cases it continues down as a prominent muscle bundle to insert on the medial aspect of the proximal phalanx. This duplication of adductor muscles is strong evidence in support of the combined action of the thumb and index as a "pollicial unit."

The *M. abductor indicis* takes origin from almost the entire length of the first and second metacarpals and at its proximal tip from the carpus. The fibers converge on a narrow tendon which passes over the lateral aspect of the metacarpo-phalangeal joint. In this region the tendon passes through a fibrous sheath passing over it from the extensor tendon. The abductor indicis is inserted on the strong circular band which surrounds the base of the phalanx and is continued on the volar surface as the annular articular ligament of the flexor tendon. The abductor indicis receives the terminal branch of the ramus profundus *N. ulnaris*. The remaining intrinsic muscles of the palm present a degree of complexity which does not lend itself readily to systematic description. There are three muscular heads taking origin on the same plane as the abductor pollicis and indicis from a central tendon extending from the lower border of the deep transverse carpal ligament. The most medial of these passes to the lateral aspect of the fifth digit where it is joined by a deep head arising from the carpus and from the lateral aspect of the fifth metacarpal. This combined muscle forms a narrow tendon which passes over the lateral aspect of the fifth metacarpo-phalangeal joint and is inserted on the extensor tendon. It is innervated by the *ramus profundus* of the *N. ulnaris*. A small slip of the superficial head passes deep to insert on the lateral aspect of the fifth metacarpal just proximal to the metacarpo-phalangeal joint. The second head arising from this common tendon passes to the medial side of the fourth metacarpal where it is joined by a deeper head also arising from the carpus and from the medial aspect of the volar surface of the fourth metacarpal. The tendon formed by these two passes over the antero-medial aspect of the fourth metacarpal joint and inserts on the extensor tendon.

In the fourth interspace the dorsal interosseus muscle, arising from the carpus, the lateral aspect of the fifth metacarpal and the medial aspect of the fourth converges on a stout tendon which passes over the medial aspect of the fourth metacarpo-phalangeal joint and inserts on the base of the proximal phalanx of the third digit.

The third and medial superficial head arising from the central tendon joins a deeper head arising from the carpus and the lateral aspect of the fourth metacarpal. These converge on a common tendon which inserts on the extensor tendon proximal to the insertion of the third lumbrical.

On the medial and lateral aspects of the middle finger there are symmetrical muscles consisting of superficial heads arising from

the carpus and the medial and lateral aspects of the third metacarpal and deep heads which are the dorsal interossei arising from the lateral and medial aspect of the third and fourth and from the second and third metacarpals, respectively. The heads converge on tendons which pass on the corresponding sides of the metacarpo-phalangeal joint to insert on the extensor tendons.

The second metacarpal presents on its medial volar aspect a superficial head corresponding to those described above, originating from the carpus and the medial aspect of the bone and giving rise to a tendon which inserts on the extensor tendon. On the lateral aspect of the second metacarpal there is a similar superficial head with its origin on the carpus and the lateral side of the volar aspect of the bone. This inserts on the volar surface of the proximal phalanx anterior to the insertion of the abductor indicis.

All of these muscles are innervated by the *ramus profundus* of the *N. ulnaris*. This nerve curves laterally beneath the combined aponeurotic tendon of the three superficial heads of the medial group and to the volar surface of the heads of the second, third and fourth metacarpals it gives off a fine branch which terminates in a fibro-fatty pad here or is distributed to the joint. It is impossible to trace these to their termination exactly but it is assumed that they subserve proprioceptive perception.

Intrinsic Muscles of the Fifth Digit.

The *M. abductor digiti quinti* consists of a fleshy belly constituting the principal muscle mass of the hypothenar eminence. It takes origin from the volar transverse carpal ligament and from the pisiform bone. The slender rounded tendon begins halfway in its length and inserts on the base of the proximal phalanx of the fifth digit. Its functional activity is improved by the passage of this tendon through a firm fibrous ligament which is a continuation of the annular articular ligament of the flexor tendons and by a fibrous sheet extending dorsally from the border of the insertion of the *flexor digiti quinti brevis* into the extensor tendon. It is innervated by the ramus profundus of the *N. ulnaris*.

The *M. flexor digiti quinti brevis* arises by an aponeurotic tendon from the transverse carpal ligament. Its origin provides the lateral boundary of the tunnel through which the *ramus profundus* of the ulnar nerve passes. This muscle pursues a somewhat oblique course from its laterally placed origin to its insertion on the medio-lateral aspect of the base of the first phalanx of the fifth digit and on the extensor tendon. It is innervated by the ramus profundus of the *N. ulnaris*.

The *M. opponens digiti quinti* lies deep to the flexor brevis and takes origin from the carpus over the fifth carpo-metacarpal joint. Its fibers insert on the lower half of the volar surface of the fifth metacarpal. The functional significance of the firm fibrous sheath which encloses the muscle is not clear.

Intrinsic Muscles of the Pollex.

The *M. abductor pollicis brevis* takes origin from the carpus just proximal to the carpo-metacarpal joint and passes obliquely and laterally to insert on the lateral aspect of the base of the first phalanx. Its tendon is held in place by a stout fibrous sheath extending between the extensor tendon and the insertion of the flexor pollicis brevis. It receives its nerve supply from the *N. medianus*.

The *M. flexor pollicis brevis*, which is innervated by the *N. medianus*, takes origin from the volar transverse carpal ligament and passes obliquely to insert in part on the lateral aspect of the proximal phalanx and in part on the extensor tendon. Its insertion partially encircles the tendon of the abductor pollicis brevis.

The *M. opponens pollicis* is a variable muscle, not so well defined as the opponens digiti quinti. It takes origin from the volar transverse carpal ligament deep to the flexor brevis and inserts in some cases on the volar surface of the first metacarpal and sometimes in common with the flexor, but slightly proximal to it on the head of the metacarpal over the joint. Innervation is from the *N. medianus*.

The *Arcus volaris profundus* is formed from a terminal branch of the ulnar artery which accompanies the *ramus profundus* of the *N. ulnaris* beneath the superficial layer of muscles and courses beneath their origins from the medial to the lateral side of the palm supplying fine branches to the intrinsic muscles and numerous contributions to the *rete volaris carpi*. There are also fine metacarpal branches passing to the interspaces where they anastomose with both dorsal and volar metacarpal branches from the superficial volar arch and the dorsal arch.

The *M. pronator quadratus* may be revealed by separating the flexor bellies and reflecting them to either side. It is a quadrilateral sheet of muscle fibers with its origin on the volar surface of the ulna at a point somewhat higher than its insertion on the radius. Thus, the fibers sweep distally and laterally to the volar surface of the distal extremity of the radius across the interosseus membrane. When the muscle is lifted up it is found to arise also from this structure. The insertion on the radius is over a broad area of the volar surface from the lateral to the medial margin. This extensive insertion would seem to signify the importance of this muscle in the initiation as

well as the completion of pronation. It is supplied by the volar interosseous artery and the volar interosseous branch of the *N. medianus*. These latter enter its deep surface and the artery itself terminates in fine anastomotic branches which pass in the medial dorsal compartment beneath the extensor tendons to join the dorsal carpal rete.

The Shoulder Joint.

The shoulder joint (*articulatio humeri*) is a diarthrosis of the ball and socket type. As in other primates, including man, it depends on the strong muscles surrounding it and the stout tendons of their attachments for its strength. The capsule of the joint itself is relatively loose and is only thickened at those points where the muscular tendons blend with it. It surrounds the glenoid cavity of the scapula and is attached on an oblique line around the head of the humerus. On the antero-medial aspect there is an opening to give exit to the tendon of the long head of the biceps which is intra-articular up to that point from its origin. This tendon passes over the head of the humerus from its origin on the supraglenoid tubercle of the scapula. The second muscle entering into intimate relations with the joint capsule is the *M. subscapularis*. The tendon of this muscle sweeps anteriorly about the neck of the humerus and its upper fibrous border blends with the capsule of the joint. This tendon forms a thickened ligament presenting a free margin within the joint cavity. There is a notch in the edge of the glenoid cavity into which the subscapular tendon fits. The portion of the subscapular tendon forming this ligament can be traced to the scapula and evidently limits external rotation of the humerus, since the muscle fibers are reduced in number in this part of the muscle.

The *Ligamentum acromio-claviculare* has a strong attachment to the anterior tip of the acromion, beneath the acromio-clavicular joint. It curves superiorly to attach to the under surface of the clavicle just proximal to the acromio-clavicular joint, forming the posterior retaining ligament of this articulation.

The *Ligamentum coraco-claviculare* extends from a point on the inferior surface of the clavicle just a short distance beyond the *L. acromio-claviculare* and curves medially to the base of the coracoid process. There is a strong band of fibers which curves upward from the acromion to the clavicle and down to the coracoid process, uniting the foregoing, and while it appears to be a separate ligament, the separation is undoubtedly artificial and this complex may be considered as a unit.

This combined ligament constitutes an arch through which the tendon of the supraspinatus passes to its insertion into the greater tuberosity. (The deltoid branch of the dorsal scapular nerve passes under this arch also). Posteriorly the joint is covered by the tendons of the supraspinatus, the infraspinatus, and the teres minor. Deep to the first two there are bursae separating the tendons from the joint capsule.

The *Articulatio acromio-claviculare* is a simple diarthrosis with a stout capsular ligament and an articular cartilaginous disc. The tip of the clavicle articulates with the anterior aspect of the tip of the acromion.

The Articulatio Cubiti and Adjacent Deep Structures.

It is necessary to remove all the muscles about this joint in order to reveal its structures completely, and as this is done the relation of these to the joint may be reviewed. Anteriorly the broad tendon of the *M. brachialis* is found to cross from the lowest point of origin on the anterior aspect of the humerus some distance above the coronoid fossa to its oblique longitudinal insertion on the antero-medial aspect of the ulna. This insertion is about a centimeter in length and begins at a point just beyond the processus coronoideus.

The *Articulatio Cubiti* includes the humero-ulnar, the radio-humeral and the proximal radio-ulnar articulations. The *capsula articularis* is relatively more restrictive than the capsule of the shoulder joint and presents a number of thickenings and accessory ligaments which both strengthen and limit the movements of which the joint is capable. There are irregular thickenings between the antero-lateral aspect of the humerus running obliquely to the coronoid process of the ulna. The anterior aspect of the radio-humeral joint is likewise thickened. The latter is exceptionally stout and consists of exceedingly dense fibrous tissue. It is firmly attached to the ulna at each end of the shallow semi-lunar articular facet.

The *ligamenta collateralia ulnaris* and *radialis* consist of strong fanshaped flat ligaments extending from the inferior aspects of the medial and lateral condyles respectively to the ulna and annular ligament of the radius.

The strongest and most prominent accessory ligament is the *chorda obliqua*. This stout ligament extends between the anterior aspect of the medial apicondyle and the posterior surface of the radial tuberosity proximal to the insertion of the *M. biceps*. Just beyond its attachment to the epicondyle it sends an oblique and medially directed band which passes over the medial aspect of the base of the coronoid process to the ulna. These two limit the extent of supination. In any position, except with the arm in extreme medial rotation, complete supination of the wrist is prevented by this band.

The *Ligamentum annulare radii* is a stout

thickening of the capsule of the radio-ulnar joint. It surrounds the neck of the radius presenting a strong attachment to the base of the coronoid process passing beneath the chorda obliqua.

When the elbow joint is opened anteriorly a very stout, partly intra-articular ligament is found extending fan-like from a broad base in the coronoid fossa. This converges on a narrow rounded band which fuses at right angles with the *Ligamentum annulare radii*. It also sends a slender band of insertion on the lateral aspect of the processus coronoideus of the ulna. The lateral border of this ligament presents a free margin within the joint, but its medial fibers are fused with the part of the capsule over the medial condyle. This ligament has no counterpart in the human being. It definitely limits extension and by the fibers coming from the anterior aspect of the medial epicondyle limits supination as well.

When the joint is fully opened, a thickened fold of the posterior part of the capsule forms a ligament somewhat like the last described. This has a similar concave free margin within the joint. The fold curves from the lateral epicondyle of the humerus medially and downward over the posterior aspect of the articular surface of the ulna. As it crosses over this to insert in the medial border of the *incisura semilunaris*, the medial border of it likewise becomes free and this narrow band of fibrous tissue covered by synovial membrane lies between the articular surfaces of the trochlea of the humerus and the incisura semilunaris of the ulna.

Between the head of the radius and the lateral condyle of the humerus, laterally there is a pad of fibro-fatty tissue covered by the synovial membrane, constituting a fold or plica which seems to complete the incisura radialis. These folds are present in all of the joints thus far described wherever the irregularities of the bones leave interstices.

The insertion of the tendon of the *M. biceps brachii* is on the dorsal aspect of the tuberosity of the radius. When this tendon is reflected medially a bursa between the tendon and the bone is disclosed. With the forearm fully supinated it is seen that the plane of this insertion lies anterior to that of the brachialis of the ulna, although the lines of insertion are parallel and in pronation they lie in the same antero-posterior plane.

Lateral to the biceps tendon, covering the entire volar surface of the radio-humeral joint and the neck of the radius, is the *M. supinator*. The medial side of this muscle partially encircles the biceps tendon; a narrow bundle of fibers extends downward to insert at the base of the insertion of the chorda obliqua. The principal insertion of the supinator is wrapped about the lateral volar and dorsal aspect of the upper third of the radius. It meets the insertion of the pronator teres at an acute angle.

The *Membrana interossea* is a stout fibrous sheet extending between the respective *Cristae interosseae* of the radius and ulna. The proximal attachment is at a higher point on the radius, just below the radial tuberosity and this free border extends downward obliquely to the ulna. The fibers present an interlacing structure beyond this point. It serves as an additional surface of origin for the deeper volar and dorsal muscles and also limits supination.

The Wrist Joint.

The wrist is a relatively loose condyloid joint permitting free motion dorso-ventrally and from side to side. Before describing the joint proper, it is convenient to review the terminations of long tendons inserted about the joint.

The tendon of the *M. flexor carpi radialis* may be examined first. This tendon lies on the volar surface of the wrist, entering its own proper sheath and passing through a compartment in the superficial part of the transverse carpal volar ligament. It is retained in this region laterally by the uncinate process of the *Os multangulum majus*. It may give off a slip here to insert in the central portion of the transverse volar carpal ligament and the palmar fascia. (Note: the palmaris longus may be absent). The remainder of the tendon plunges deeply to terminate about the first, second and third carpo-metacarpal joints. Its insertions here are not constant. In some cases there are slight slips to the base of the first metacarpal, but the principal termination is on the base of the second metacarpal. Functionally, it must be recognized that the rigidity of the second, third, and fourth carpo-metacarpal joints renders this insertion essentially that of a flexor of the carpus and of the central metacarpals with the latter.

The tendon of the *M. flexor carpi ulnaris* inserts on the *Os pisiforme* which rests on the volar surface of the *Os triquetrum*. The tendon is continued downward distally to insert on the base of the fifth metacarpal. Here it lies medial to the *hamulus ossis hamatum* and lies in a groove on the lateral surface of this process. (*c.f. infra*: Ligaments of the *Os pisiforme*).

While these flexor tendons insert on opposite sides of the carpus, the pull of the muscles is not only in the direction of flexion, but also of ulnar deviation of the hand and assists in pronation. The pronated position of the hand is most effective in sustaining flexion of the fingers by aligning the strong ulnar origins with the point of chief pull in the carpal canal.

The transverse carpal ligament may be considered as consisting of superficial and deep parts which are fused on the medial and lateral aspects of the carpus to form the flexor tunnel, or as a circular collar resting on the volar aspect of the carpus and held in place by strong attachments to the triquetrum and pisiform medially, the navicular and multangulum majus laterally, and the capitate centrally. It fuses proximally with the capsule of the radio-carpal joint. There is a stout radio-capitate ligament extending from the volar surface of the base of the radius to the volar surface of the capitate bone. When the wrist joint is opened from the dorsal surface a number of important retaining ligaments are revealed. The first of these is the first portion of the dorsal carpal ligament which extends obliquely from the radius to the dorsum of the triquetrum and its continuation in the triquetro-lunate ligament which together form the canal through which pass the tendons of the extensor digitorum communis. When the radio-carpal joint is opened the adjacent articular surfaces of the navicular and lunate are exposed. The concave articular surface of the radius facing them presents about its rim a fibro-cartilaginous labrum. From the edges of this the articular capsule extends to the carpus. The labrum is continuous with the fibro-cartilaginous disc between the base of the radius and head of the ulna and with an interarticular ligament consisting of two parts. The dorsal portion extends from the radio-ulnar articulation to the triquetro-lunate articulation. The volar portion of this interarticular ligament is found to consist of the deeper fibers of the radio-capitate ligament. The *articulatio ulno-carpalis* is between the head of the ulna and the triquetrum and pisiform. The ulnar surface is convex, fitting into the depressions of the articular surfaces of the triquetrum and pisiform. This is the reverse of the radio-carpal joint where the concave surface is presented by the radius. The volar ligament extends from the radio-ulnar fibrocartilage to the pisiform and the volar surface of the triquetrum. Further exposure of the joint reveals the volar radio-carpal ligament. This is a fanshaped ligament extending from the entire width of the radius on the volar aspect of the margin of the articular surface converging on the volar aspect of the lunate.

On the volar aspect of the pisiform there are three stout ligaments diverging distally as follows: The proximal one extends from the pisiform to the *Os multangulum majus;* the intermediate one extends from the pisiform to the proximal aspect of the base of the *hamulus* of the *Os hamatum;* and the distal one extends to the volar surface of the base of the fifth metacarpal, just beyond the carpo-metacarpal joint.

When the carpal joints are further exposed from the dorsal surface, the hamate and capitatum are found to fit closely to each other and form a rounded proximal surface which articulates with correspondingly concave articular facets of the proximal row. The sharp distal edge of the *Os centrale* forms the lateral lip of this cup and intervenes between the lateral aspect of the *Os lunatum* and the medial aspect of the *Os multangulum minus* and the *Os multangulum majus* which lies somewhat volarward with respect to the lesser multangulum.

The articulations of the metacarpals and the carpal bones are as follows: The first metacarpal articulates exclusively with the *Os multangulum majus.* The second articulates with the *Os multangulum majus* and *minus.* The third articulates with the *Os capitatum.* The fourth with a very narrow facet on the capitatum and a broad area of the *Os hamatum.* The fifth articulates with the hamatum alone. The *Os centrale* is disc shaped and articulates with and rests in a notch on the distal surface of the navicular bone and by its tight interosseus capsular ligaments forms essentially an integral part of the navicular. When fully isolated the carpus is seen to be curved from side to side with the concavity on the volar surface. The volar rims are formed on the radial side by the *Os navicularis* proximally and the *Os multangulum majus* distally and on the ulnar side by the proximal *Os pisiforme,* which lies wholly on the volar aspect of the carpus, and the distally situated hamulus of the *Os hamatum.* On the volar surface the stout triquetro-lunate ligament forms the basis of the transverse carpal ligament. This extends upward to bind the pisiform firmly in this unit and continues laterally to form the naviculo-lunate ligament.

The distal row of carpal bones is similarly connected by strong volar interosseus ligaments but these are somewhat less distinct than those of the proximal row. Examination of the bases of the metacarpal bones shows them to articulate very closely with one another, and the interlocking articulations between adjacent metacarpals indicates the relative rigidity of this area. The sole exception is the first metacarpal which has no articulation with the second, of the kind noted between the others, and lies in a distinctly volar plane with respect to the base of the second. There is, however, a tubercle on the volar aspect of the base of the second metacarpal and into the groove between this and the base proper, the first metacarpal fits. The connection here, as between the bases of the others on both dorsal and volar aspects, is by stout limiting ligaments.

The Scapula is a thin, flat bone, trian-

gular in shape, with a broader thickened inferior axillary margin which forms an acute angle with the medial or vertebral margin. The shorter superior margin joins the vertebral margin almost at right angles, although this posterior superior angle is rounded. The bone is concave on its deep surface which is applied to the posterior thoracic wall. This concave surface presents three ridges running from the vertebral margin and converging on the neck or lateral angle. The dorsal convex surface bears in its upper part the perpendicular *Spina scapulae* which begins some distance from the vertebral margin, sloping upward to its crest and terminating in the acromion process which is directed anteriorly and superiorly overhanging the glenoid fossa. At the neck the bone is thickened and this lateral angle bears on its summit the shallow, ovoid articular surface for the humerus.

Arising from the superior border, near the neck, is the coracoid process. This is thick at the base and directed anteriorly at an obtuse angle, with respect to the superior border. There is a deep notch in the superior border near the base of the coracoid process. In some specimens the posterior tip of the coracoid process, to which is attached the *Ligamentum transversum scapulae superius*, may be partially ossified, almost closing the incisura to form a foramen. The lateral aspect of the coracoid process projects laterally and downward to support the strong origins of the *caput breve M. biceps* and the *M. coracobrachialis* and *M. coracohumeralis* (*coracobrachialis profunda*).

The *Spina scapulae* divides the posterior surface into the deep supraspinous fossa and the more shallow but broader infraspinous fossa. The inferior margin of the latter is formed by a prominent ridge of bone which in part overhangs the inferior border. The overhang is more definite as it approaches the lateral angle.

The crest of the spine presents an S-shaped curve, the posterior limb directed superiorly near the vertebral border and the anterior or lateral limb directed inferiorly. In the concavity of the lateral curve is the depression for the origin of the spinous division of the *M. deltoideus*.

The inferior ridge gives a broad area for the origin of the long head of the *M. triceps* and for the *Mm. teres major* and *minor*. This may be described as the *Crista infraglenoidalis*.

The *Cavitas glenoidalis* is on a flattened ovoid prominence with its plane at right angles to the body of the bone, occupying the lateral angle. The very shallow depression has regular margins and is pointed superiorly, being narrowed anteriorly by a groove in which the tendon of the subscapular muscle rests. Above the pointed tip is a facet, the *Tuberositas supraglenoidalis* for the attachment of the *caput longum* of the *M. biceps*.

The *clavicle* (clavicula) is a short, slender, cylindrical bone with an S-shaped curve. It is divisible into a shaft and two extremities. The clavicle occupies an oblique position on the anterior aspect of the thorax, forming an angle of about 45° with the mid-sagittal line. The shaft is bent convexly forward for almost two-thirds of its length and the convexity backwards is sharper and more acute than the medial curve. The *extremitas sternalis* is broadened and presents a convexity on its anterior aspect which constitutes the roughened surface for the clavicular attachment of the strong sterno-clavicular ligament. The *facies articularis sternalis* is covered with cartilage and consists of a narrow border directed medially. This lies on the curve of the spoon-shaped sternal extremity. The *extremitas acromialis* is somewhat broadened and occupies roughly one-fifth of the length of the bone. It is flattened from above downwards and the under surface presents a rough concave area for the attachment of the coraco-clavicular ligament. The extreme tip of the bone which articulates with the acromion is blunt, and, as noted in the discussion of that joint, occupies a very small and insignificant area. On the convexity of the lateral curve there is a small roughened area to receive the insertion of the *M. subclavius*.

The Humerus is a long, cylindrical bone articulating with the scapula above and the radius and ulna below. It presents a shaft or corpus and two extremities. The corpus is distinctly cylindrical above and flattened antero-posteriorly below.

The upper extremity is broadened and supports the *caput humeri* which is hemispherical in shape, the base joining the extremity at an acute angle. The articular surface of the head comprises an area somewhat greater than twice that of the glenoid cavity of the scapula. The caput humeri is separated from the shaft by a constricted area, the *collum anatomicum humeri*. On opposite sides this bears the larger lateral *tuberculum majus* and the smaller, medially placed *tuberculum minus*. Between the two there is a deep groove, the *sulcus intertubercularis*. Below, this depression becomes shallower, but in the upper part it is bordered by two crests of bone. The *crista tuberculi majoris* may project or overhang the sulcus in its upper part. This crest may be traced distally to the lower limit of the deltoid surface, in the middle third of the corpus.

The *crista tuberculi minoris*, which is a broad flattened ridge extending downward from the base of the tuberculum minus, disappears for a short distance to rise again with a sharper crest for the attachment of the *Mm. latissimus dorsi* and *teres major*.

The *Tuberculum minus* in adult specimens presents a broad flat facet on its medially facing apex for the stout insertion of the *M. subscapularis.*

The *Tuberculum majus* presents three oval facets on its superior surface near the junction with the *collum anatomicum;* the two more lateral ones touching and partially surrounding the medial one. These serve for the insertions of the *Mm. supraspinatus, infraspinatus,* and *teres minor* from above downward.

It should be noted that the *crista tuberculi majoris* crowns the summit of an anteroposterior curve of the corpus humeri in its upper third. The apex of this curve, which continues through the greater length of the humerus, lies at the lower point of the insertion of the *M. deltoideus,* in the middle third of the shaft. This is a double curve being from medial to lateral in the middle third of the humerus as well as anteroposterior throughout. The broad flat area extending downward from the *tuberculum majus* serves for the insertion of the deltoid.

The lower extremity of the humerus, consisting largely of the lower third, is flattened from before backward and is much broader than the shaft or the upper extremity. From each side there are rough projections of some size, the medial being considerably more prominent than the lateral. These are the respective epicondyles which give attachment for the ligaments of the joints and for the extensor and flexor groups of muscles of the forearm. Between these lie the articular surfaces of the inferior extremity. This surface bears an oblique relationship to the shaft of the humerus.

The medial of these two surfaces is the roller-shaped *trochlea* which articulates with the *incisura semilunaris* of the ulna. The lateral surface is the rounded *capitulum* with its prominent convexity presenting largely anteriorly. The trochlea, on the contrary, extends around for a considerable area posteriorly.

Above the junction of the trochlea and capitulum anteriorly there is a very shallow depression, the *fossa coronoidea.* Lateral to the latter is the deep rounded *fossa radialis.* The relative depth and development of these is the reverse of conditions in man. This in turn may be related to the greater participation of the radius in the elbow joint. Posteriorly, extending from epicondyle to epicondyle, the *fossa olecrani* occupies the breadth of the inferior extremity.

The *Ulna* is a long, cylindrical bone with a very large, thick, proximal or upper extremity and a long, slender shaft terminating in the small lower extremity or head. The upper extremity articulates with the humerus by means of the deep saddle-shaped *incisura semilunaris* which presents a high proximal crest from the *olecranon,* and the equally well developed *processus coronoideus* distally. On the lateral aspect of the latter, facing anteriorly and obliquely laterally, is the shallow depression of the *incisura radialis.* The coronoid process shows medially a flaring surface which gives added area for the articulation with the *trochlea humeri.* This flare is definitely more medial than that of the olecranon, which is on a line with the *incisura radialis.* This latter alignment accounts for the fact that the *fossa radialis* and the *fossa olecrani* lie opposite each other on the humerus.

Distally at the base of the coronoid process there is a crest of some size which slopes posteriorly to end on the facies medialis of the ulna. This serves for the insertion of the *M. brachialis.* The olecranon is a roughened stout process of the upper extremity distinctly separated by an appreciable interval from the crest forming the superior lip of the incisura semilunaris. Its proximal surface is irregularly flattened for the insertion of the tendons of the triceps complex. Medially there is a separate facet for the insertion of the *M. dorsoepitrochlearis.* The upper extremity of the ulna is flattened from side to side and from the coronoid process to the junction with the middle third is three to four times as wide as the lower part of the shaft. This region is constricted also between the anterior border and the posterior subcutaneous border.

The shaft of the ulna presents a distinct curve with the convexity directed posteriorly. In the lower third, the distal extremity becomes cylindrical and exhibits a prominent crest for the origin of the *M. pronator quadratus.* Below this the bone widens somewhat and terminates in two projections of about equal size, the proximal *capitulum* which articulates by a synostosis with the radius, and the longer distal *processus styloideus* which articulates directly with the concavity of the *Os triquetrum* and to a slight extent with the *Os pisiforme.* The *foramen nutricium* is found proximally on the medial or lateral surface of the flattened area some distance beyond the coronoid process. It is directed proximally.

The *Radius* is a long, slender, cylindrical bone with a prominent well-developed head bearing a shallow circular depression, the *fovea capituli radii,* for its articulation with capitulum humeri. Medially there is a semilunar convex area for the *incisura radialis* of the ulna—this is the *circumferentia articularis.* Just below the capitulum the bone is narrowed to form the *collum radii* and close below this is a rounded projection directed medially, the posterior rim of which serves for the insertion of the flattened tendon of the *M. biceps.* The anterior bulge of this *tuberositas radii* serves as a fulcrum increasing the mechan-

ical efficiency of this insertion. Distal to the tuberosity is the beginning of a laterally directed curve in the shaft which has its convexity in the middle third. To the summit of this curved area the *M. pronator teres* has its broad insertion. The volar surface of the radius is obliquely flattened, sloping posteriorly to the interosseous crest.

The broad lower extremity is flattened in a dorso-ventral plane; the anterior surface serving for the insertion of the *M. pronator quadratus*. The articular surface of the lower extremity faces toward the medial or ulnar side of the arm and bears thus an oblique relation to the shaft of the bone. The *processus styloideus* is a flat projection constituting the lateral border of this articular surface. Medially there is a shallow depression for articulation with the ulna, but as described in the section on the wrist joint this articulation is not by true articular surfaces. Dorsally the distal extremity presents a prominent crest which is broad at its base and separates two deep grooves. The medial one is for the tendons of the *M. extensor digitorum communis*. The lateral groove serves to retain the strong tendons of the *M. abductor carpi radialis* and the *Mm. extensores carpi radialis brevis* and *longus*.

The carpal bones will not be considered individually; they have been discussed in connection with the wrist joint.

The point of chief interest in the phalanges is the striking curve of the proximal phalanges of digits two, three and four, especially. This curve has its convexity dorsally and the volar surface presents a deep groove into which the flexor tendons are tightly bound by the annular ligaments. It is suggested that this great curve increases the mechanical efficiency of the fingers in forming a rigid hook once flexion of the metacarpo-phalangeal joints passes beyond the 90° angle.

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EXPLANATION OF THE PLATES.

Plate I.

Fig. 1. *Lagothrix*. Dissection of shoulder region.

Plate II.

Fig. 2. *Lagothrix*. Medial aspect of arm and volar surface of forearm.

Plate III.

Fig. 3. *Lagothrix*. Flexor tendons in carpal canal.

Fig. 4. *Lagothrix*. Extensor tendons.

Plate IV.

Fig. 5. *Lagothrix*. Lateral view of metacarpophalangeal joint.

Fig. 6. *Lagothrix*. Superficial muscles of the palm.

Fig. 7. *Lagothrix*. Extensor tendons and their insertions on the phalanges.

Fig. 8. *Lagothrix*. Flexor tendons and their insertions on the phalanges.

Fig. 9. *Lagothrix*. M. flexor digitorum profundus tendons. Volar aspect.

Plate V.

Fig. 10. *Lagothrix*. Deep muscles of the palm (volar interossei, intrinsic muscles of thumb, index and fifth digit).

Note: The relation of the flexor carpi radialis tendon to its insertion is not clearly shown here. x and y are the os navicularis and os multangulum majus to which the sheath of this tendon is bound. It does not insert on them.